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THE UNIVERSITY OF ALBERTA

EFFECT OF PHYSIOTHERAPY INTERVENTION ON EARLY KNEE RECOVERY FOLLOWING ARTHROSCOPIC PARTIAL MENISCECTOMY

by

Lori Ellen Macdonald

(C)

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF Master of Science

Department of Physical Therapy

EDMONTON, ALBERTA

Spring 1990

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled EFFECT OF PHYSIOTHERAPY INTERVENTION ON EARLY KNEE RECOVERY FOLLOWING ARTHROSCOPIC PARTIAL MENISCECTOMY submitted by Lori Ellen Macdonald in partial fulfilment of the requirements for the degree of Master of Science.

.....
Dr. D.J. Magee

.....
Dr. D.W.C. Johnston

.....
Dr. J. Wessel

.....
Dr. Y. Bhambhani

Date: FEB 20 1990

To my parents

Ellen and Alexander F. Macdonald

ABSTRACT

The purpose of this study was to determine if physiotherapy intervention prior to arthroscopic knee meniscectomy had a measurable effect on knee pain, range of motion, and knee extensor muscle strength during the first three weeks following surgery. Sixteen men and four women, between 17 and 54 years of age, were divided into two groups. Ten subjects were seen by a physiotherapist prior to surgery and 10 acted as controls. All subjects were evaluated one, two, and three weeks following surgery. Pain was measured using a visual analogue scale. A goniometer was used to assess active knee range of motion. Knee extensor muscle torque was evaluated at 60 and 240 degrees per second on a Cybex II isokinetic dynamometer.

The pain, range of motion, and strength data were analyzed separately using an analysis of variance with repeated measures design. Analysis of the pain data revealed a significant Group x Time interaction (p=.022). The time effect was significant for the range of motion data (p=.00004). Analysis of the strength data revealed significant time (p=.00002), and velocity (p=.637E-7) effects. The results suggested that physiotherapy intervention prior to arthroscopic knee meniscectomy had no significant effect on knee pain, range of motion, and knee extensor muscle strength during the first three weeks

following surgery. It is recommended that additional studies be conducted to determine the role of the physiotherapist in the rehabilitation of arthroscopic meniscectomy patients.

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I. INTRODUCTION

Excision of the meniscus of the knee is one of the most common orthopaedic procedures (Lysholm & Gillquist, 1981). At one time, total meniscectomy via open arthrotomy was the recommended method of treating suspected meniscal tears (Duthie & Ferguson, 1973). Many surgeons, when confronted with an apparently normal meniscus at arthrotomy followed the dictum "if in doubt, take it out" (Noble & Turner, 1986).

The philosophy of treating meniscal tears has changed dramatically over the years (Ferkel et al., 1985). A particularly striking and relatively recent change is the performance of meniscectomy under arthroscopic control rather than via conventional open arthrotomy. In North America, from 1965 to 1975, "arthroscopy advanced from a medical curiosity to a useful adjunct in the treatment of joint disease" (Jackson, 1987, p.3).

Arthroscopic meniscectomy is an operative procedure that causes pain and effusion (Sherman, 1987; Zarins, Boyle, & Harris, 1985). Effusion has been shown to produce reflex inhibition and subsequent atrophy of the quadriceps muscle (deAndrade, Grant, & Dixon, 1965; Spencer, Hayes, & Alexander, 1984). Simple measures such as ice, elevation, exercise and modification of activity have been shown to minimize pain and effusion and enhance early recovery of

function (Sherman, 1987; Spencer et al., 1984; Stanitski, 1985; Zarins et al., 1985).

The benefits of arthroscopic meniscectomy compared to conventional open arthrotomy are evident. Arthroscopic patients have less pain and less restriction of knee mobility immediately following surgery (Klein & Schulitz, 1983). Rate of recovery based on criteria such as length of hospitalization, need for walking aids and time to return to work or sport is more rapid (Klein & Schulitz, 1983; Tregonning, 1983).

A lower incidence of complications following arthroscopic meniscectomy has also been reported (Jackson, 1983; Sherman et al., 1986). The procedure can be performed on an outpatient basis under local or general anesthesia (Lysholm & Gillquist, 1981). The financial implications are considerable because hospitalization may be minimized or eliminated and patients generally resume working shortly after surgery (Tregonning, 1983).

Statement of the problem

The role of physiotherapy in the management of the arthroscopic meniscectomy patient has not been determined. Most studies alluded only briefly to postoperative treatment. At best, a few short lines indicated that the patient was given written and/or verbal exercise instructions (Hamberg, Gillquist, Lysholm, & Oberg, 1983)

and was discharged home with or without walking aids. Usually, outpatient physiotherapy was not prescribed (Tregonning, 1983). At present, physiotherapy plays a relatively insignificant role in the management of arthroscopic knee patients.

Physiotherapy has not been routinely prescribed before or after arthroscopic meniscectomy. The question "why not?" has not been addressed directly in the literature. There was also little evidence to conclusively justify that physiotherapy was indicated. Very few studies have attempted to evaluate the effect of physiotherapy intervention on functional knee recovery following arthroscopic meniscectomy. Prevailing opinion suggested that because patients appeared to recover so quickly after arthroscopic meniscectomy, physiotherapy intervention was not warranted.

Objective of the study

In the present study, the effect of direct physiotherapy intervention on early knee recovery following arthroscopic partial meniscectomy was evaluated. Knee pain, mobility, and strength of two groups was assessed during the first three weeks following surgery. Subjects in the treatment group were personally visited by a physiotherapist once prior to surgery. Subjects in the control group were not seen by a physiotherapist.

Significance of the study

The results of this study contributed additional knowledge regarding the progression of knee recovery during the first three weeks following arthroscopic meniscectomy. The results also indicated if preoperative instructions, delivered to a patient by a physiotherapist, had any measurable effect on knee pain, range of motion, and knee extensor muscle strength during the first three weeks following arthroscopic surgery.

Research hypothesis

This study was designed to test the specific hypothesis that direct physiotherapy intervention prior to arthroscopic partial meniscectomy resulted in less pain, greater range of motion, and greater knee extensor muscle strength during the first three weeks following surgery.

Operational Definitions

(1). Activity level - usual frequency of participation (days per week) in aerobic activities such as cycling, walking, jogging or swimming, of at least 20 minutes duration, during the six months preceding surgery.

(a). moderate - 3 days per week or less.

(b). high - 4 days per week or more.

(2). Cybex II® [1] isokinetic dynamometer - a testing and exercise device that measures torque throughout the complete range of motion of a joint at a constant selected velocity while accomodating resistance to the muscular tension produced. Velocities between zero to three hundred degrees per second can be selected (Wyatt & Edwards, 1981).

(3). TEC® [2] goniometer - a clear plastic device consisting of a 360 degree protractor and two arms. The "stationary arm" extends from the protractor. The "mobile arm" is attached via a rivet to the center of the protractor.

(4). Strength - the average peak torque of 3 consecutive, maximal, concentric contractions of the knee extensors at two velocities: 60 degrees per second and 240 degrees per second.

(5). Torque - the force acting about an axis of rotation. It is equal to the force multiplied by its perpendicular distance from the axis of rotation (Moffroid, Whipple, Hofkosh, Lowman, & Thistle, 1969). Torque in this study was measured in foot-pounds.

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[1]Cybex, Division of Lumex Inc., Ronkonkoma, New York

[2]TEC, New York City, New York

(6). Trained nurse - a registered nurse, working in the day surgery clinic at the University of Alberta Hospitals, who has been instructed to simply hand a copy of the instruction/exercise sheet to subjects in the control group and say "Here is a pamphlet to read". The nurse did not offer any additional encouragement, explicit instuctions, or clarifications about the information on the sheet.

(7). Trained physiotherapist -

(a). a physiotherapist certified by the College of Physical Therapists of Alberta and a physiotherapy staff member of the University of Alberta Hospitals. This individual gave written and verbal instructions to the subjectsin the treatment group prior to surgery.

(b). a second physiotherapist, certified by the College of Physical Therapists of Alberta, with 4 years of general clinical experience who had demonstrated proficiency to reliably measure knee range of motion and peak torque, correctly calibrate the Cybex II, and execute the isokinetic tests described in this study. This individual evaluated all the subjects who participated in this study.

Delimitations

Results were limited to:

(1). individuals who satisfied the inclusion criteria for participating in this study.

(2). individuals who were given the instruction/exercise sheet (Appendix A) used in this study.

(3). knee extensor strength measured at the two velocities (i.e. 60 degrees and 240 degrees/s) selected for this study.

Limitations

(1). There was no control of the physical activities, such as walking or sports, subjects may have participated in following surgery.

(2). There was no control of modalities such as whirlpool or heating pads subjects may have used following surgery.

(3). Subjects may have behaved differently than they normally would have because of their involvement in the study.

(4). Precision of the pain values were limited by the ability of subjects to evaluate their level of pain intensity and to graphically record that level on a visual analogue pain scale.

(5). Precision of the range of motion values were limited by the accuracy of the goniometer used and by the

reliability of the physiotherapist measuring active knee mobility.

(6). Precision of the strength values were limited by the reliability of the physiotherapist to measure peak torque.

(7). Strength values were limited to the ability of the subjects to exert maximal effort during the testing.

Ethical considerations

Very little agreement exists in the medical community about the role of formal rehabilitation following arthroscopic meniscectomy (Zarins et al., 1985). At the University of Alberta Hospitals, arthroscopic knee surgery patients usually do not receive an instruction/exercise sheet. In this study, all subjects received a standard knee instruction/exercise sheet. Beneficial effects of physiotherapy following arthroscopic partial meniscectomy have not been demonstrated conclusively. Therefore, concern about withholding treatment from the control group in this study was not warranted.

Potential risks to the subjects participating in this study were expected to be minor and short-lived. The potential risks identified included mild thigh muscle soreness and/or slight irritation of the knee joint lasting 2-3 days following strength testing. Confidentiality of the subjects was respected.

II. LITERATURE REVIEW

The literature review is arranged into three main segments and addresses the following topics:

(1). Rehabilitation programs.

(2). Benefits of arthroscopic surgery.

(3). Rehabilitation and isokinetic devices.

Rehabilitation programs

Formal rehabilitation of arthroscopic knee patients has merited little attention in the recent literature. Retrospective studies conducted to evaluate the outcome of arthroscopic surgery have alloted, at best, a few cursory lines to rehabilitation. The descriptions of the rehabilitation programs included in such studies, have generally been brief, ambiguous, and disparate.

Following arthroscopic partial meniscectomy, subjects in one study (Grana, Conner, & Hollingsworth, 1982), began an active exercise program, under the supervision of a physiotherapist, either immediately or on the first postoperative day. Details about the exercise program were not included in the article. The average hospital stay of the 46 patients who participated in the study was 2 days. Within 8 days post-op, the majority of patients had 90 degrees knee flexion. The patients were assessed using a clinical rating scale that combined a subjective and a

physical evaluation. The authors reported that 84% of the patients had a satisfactory result. These results, the authors claimed, supported the observation that partial rather than total meniscectomy shortened hospitalization and rehabilitation. The only information in the article that pertained to hospitalization and rehabilitation was the reported length of hospital stay, the mere mention that a postoperative exercise program was implemented, and the average knee mobility patients had 8 days following surgery.

In another retrospective evaluation of knee arthroscopies (Tietjen, 1987), subjects began an unsupervised program that stressed quadriceps and hamstring rehabilitation two weeks following surgery. The content of the exercise program was not discussed and no mention was made in the paper concerning who and how the program was conveyed to the patients.

In a third study (Hamberg et al., 1983), patients were given verbal as well as written exercise instructions following arthroscopic surgery. In this study as in the one by Tietjen (1987), no details concerning the exercise program were given and the qualifications of the exercise instructor were not mentioned. Patients included in the study sample were 5 women and 32 men who underwent diagnostic arthroscopy, or diagnostic arthroscopy and arthroscopic partial menisectomy for a bucket-handle or a

flap tear, arthroscopic total meniscectomy, or open meniscectomy. It was not clear from the limited details about the exercise program if all patients, regardless of their diagnosis, received the same instructions and exercises.

In a fourth study (Tregonning, 1983), the postoperative and early rehabilitation progress of patients was reviewed on average, 8 months following surgery. Patients involved in this study received instruction in physiotherapy before and after arthroscopic partial meniscectomy for bucket-handle or flap tears. No further details about the instructions or the qualifications of the instuctor were given in the article. The average hospital stay was 1 day and patients returned to work in less than 2 weeks. Using duration of hospital stay and return to work as the only criteria to assess rehabilitation, the author reported that closed partial meniscectomy was associated with rapid rehabilitation.

The exercises most commonly given to arthroscopic meniscectomy patients were straight leg raises and quadriceps setting (Besser & Stahl, 1986; Ferkel et al., 1985; Hershman & Nisonson, 1983; Prietto, Caiozzo, Prietto, & McMaster, 1983; Tregonning, 1983). Early ambulation was also encouraged in a number of studies (Ferkel et al., 1985; Patel, Fahmy, & Sakayan, 1982; Tietjen, 1978; Tregonning, 1983).

Despite these similarities, review of the literature suggested that there was little consensus regarding the rehabilitation of arthroscopic surgery patients. At one end of the scale were studies (Lysholm & Gillquist, 1981; Northmore-Ball, Dandy, & Jackson, 1983), that did not report the rehabilitative techniques used. At the opposite end of the scale was a study (Kovaleski, Craig, Costill, Habansky, & Matchett, 1988) that described a postarthroscopic meniscectomy rehabilitation program in considerable detail.

The rehabilitation program presented in the latter article included a home exercise component that involved knee range of motion, quadriceps and hamstring isometric exercises, and straight leg raises as well as a supervised isokinetic program that was performed using an Orthotron® [3] isokinetic dynamometer. The subjects, who ranged in age from 16 to 59 years, were assigned according to age, to one of three groups. All subjects followed the same rehabilitation program. Thigh strength was measured weekly using a Cybex II isokinetic dynamometer. In less than a month, subjects in all three groups achieved almost 90% recovery of strength of the surgical leg compared to the nonsurgical leg.

A few studies (Besser & Stahl, 1986; Hershman & Nisonson, 1983; Patel et al., 1982), fell between the two

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[3]Cybex, Divison of Lumex Inc., Ronkonkoma, New York

extremes of the scale. Rehabilitation was mentioned in these studies but details concerning the content of the exercise programs and how the programs were implemented were not given.

After undergoing arthroscopic surgery performed under local anesthesia, patients in one study (Besser & Stahl, 1986), were instructed to perform straight leg raise exercises and to limit activity. A variety of arthroscopic procedures including meniscectomy, cartilage shaving, or soft tissue release were performed on patients involved in this study. Patients left the hospital within an hour of completion of surgery. The authors concluded that arthroscopic surgery performed under local anesthesia reduced the complications that might have occurred if general or epidural anesthetics were used.

In a second study (Hershman & Nisonson, 1983), patients began both straight leg raise and quadricep setting exercises following arthroscopic partial meniscectomy. The qualifications of the instructor of the exercises were not mentioned. At 12-24 months postoperative follow-up, 92% of the patients rated their knees as normal or improved on a self-report evaluation questionnaire.

In a third study (Patel et al., 1982), patients scheduled to undergo arthroscopic surgery for three conditions - partial synovectomy, meniscectomy, and

meniscectomy associated with anterior cruciate deficiency, received preoperative instruction from a physiotherapist. Following surgery, patients began a regimen of isometric exercises and progressed to active-resistive exercises. The exercises were not described nor was the instuctor of the exercises identified.

Thigh strength of all patients was evaluated periodically using the Cybex II. Patients in the partial synovectomy group recovered 90% strength of the surgical leg, relative to the uninjured leg, in 4 weeks compared to 6 weeks for the meniscectomy group and 8 weeks for the anterior cruciate deficient meniscectomy group. Patients in all three groups resumed normal routine activities and returned to sports and recreation long before they regained 90% strength of the surgical leg. The reported return to routine activity following surgery was 3 days for the partial synovectomy group, 5 days for the meniscectomy group, and 7 days for the anterior cruciate deficient meniscectomy group. The reported return to sports was 6 days (partial synovectomy group), 11 days (meniscectomy group), and 10 days (anterior cruciate deficient meniscectomy group).

The majority of studies conducted to review the postoperative progress of arthroscopic meniscectomies have been long-term, and retrospective in nature (Grana et al., 1982; Hershman & Nisonson, 1983; Lysholm & Gillquist, 1981;

Northmore-Ball et al., 1983). Typically, information about knee recovery was obtained one year or more after surgery from patient self-report questionnaires (Lysholm & Gillquist, 1981) or from a combination of both questionnaires and clinical examinations (Hershman & Nisonson, 1983; Northmore-Ball et al., 1983). Simple indicators such as duration of hospitalization and time to return to work or sport were commonly used to assess the rate of early recovery. There was a noticable lack of objective and refined measures to evaluate recovery of mobility, strength and function.

In one study (Lysholm & Gillquist, 1981), patients completed a knee scoring-scale evaluation 2-51 months following surgery. Patients included in the study ranged in age from 18 to 75 years and underwent arthroscopic surgical techniques for the treatment of isolated meniscal tears, or meniscal tears in combination with other lesions such as ligamentous injuries or articular cartilage degeneration. Bucket-handle tears were associated with better results than were degenerative tears, and cartilage degeneration and anterolateral ligamentous instability adversely affected the result of meniscectomy. Most patients returned to work within 2 weeks and to athletic activities within 4 weeks.

Northmore-Ball et al. (1983), compared the results of three different types of meniscectomies (i.e. arthroscopic

partial, open partial, and open total meniscectomy). Patients completed a questionnaire, were interviewed by telephone, or were examined by a physician 1 to 5 years following surgery. Patients included in the study ranged in age from 17 to 68 years. Excluded from the study were patients with ligamentous instability or marked degenerative changes of the injured knee. Simple indicators such as the duration of use of walking aids, and the time to return to work or sport were used to assess the rate of early recovery. The duration of use of walking aids was much less for patients treated arthroscopically than by the other two methods (i.e. a cane for 2.1 days vs. crutches for 11.7 days for the open partial meniscectomy patients, and 25.3 days for the open total meniscectomy patients). Return to sport was also quicker for the arthroscopic patients (i.e. 5.1 weeks vs. 10.8 weeks for the open partial meniscectomy patients, and 13.7 weeks for the open total meniscectomy patients). The authors concluded that patients treated by arthroscopic partial meniscectomy did better than patients treated by open partial or total meniscectomy.

Early follow-up studies (i.e. within the first few weeks following surgery) were relatively rare compared to the abundance of long-term studies. In drug efficacy studies, pain intensity has been measured on a limited

point scale or simply on a present/absent basis (Indelicato, 1986; Ogilvie-Harris, Bauer, & Corey, 1985).

Indelicato (1986), compared the effectiveness and tolerability of two analgesics, diflunisal and acetaminophen with codeine, in patients who underwent arthroscopic surgery. Patients were assigned to one of two treatment groups and received either diflunisal or acetaminophen with codeine. One, 2, and 5 days following surgery, the patients reported their degree of pain using a 4-point pain-rating scale that ranged from no pain to severe pain. The results indicated that diflunisal and acetaminophen with codeine were equally effective in relieving pain. On the first postoperative day, 57% of the patients treated with diflunisal and 73% of the patients treated with acetaminophen with codeine reported moderate pain. Three days after surgery, 57% of the diflunisal group and 63% of the acetaminophen with codeine group reported mild pain. Five days after surgery 100% of patients in both groups reported no pain.

In another study (Ogilvie-Harris et al., 1985), the effect of a prostaglandin inhibitor on rate of recovery after arthroscopic meniscectomy was evaluated. Patients were assigned to one of two groups (i.e. prostaglandin inhibitor or placebo group). Factors assessed in evaluating knee recovery included pain, synovitis and effusion, mobility, and quadriceps atrophy. At follow-up

visits 7, 21, 42, and 84 days after surgery, patients reported the presence of pain at rest, with normal daily activities, and with increased activities and sport. The term "increased activities" was not operationally defined in the study. Patients in the prostaglandin inhibitor group reported significantly less pain at rest up to 21 days after surgery, and less pain during activity at all times than patients in the placebo group. Seven and 21 days following surgery, the percentage of patients in the prostaglandin group who reported no pain at rest was 75% and 95% versus 40% and 78% of patients in the placebo group. The percentage of patients in the prostaglandin group who reported no pain with normal activities at 7 and 21 days was 62% and 78% versus 12% and 25% of patients in the placebo group.

The effect of a prostaglandin inhibitor on recovery following open meniscectomy was also evaluated in another study (Muckle, 1984). Patients in one group underwent open partial meniscectomy, while patients in the other group underwent open total meniscectomy. The two groups were subdivided. One-half of the patients in each of the two original groups received an analgesic while the other half received a prostaglandin inhibitor. Knee pain, swelling, mobility and strength were assessed regularly. Pain was evaluated on a 4-point scale that ranged from no pain to severe pain. One day after surgery, patients in all four

groups reported moderate pain. Seven days following surgery, partial and total meniscectomy patients who received a prostaglandin inhibitor reported no pain or mild pain. In contrast, patients who received the analgesic were not free of pain until 14 days following surgery.

It was reported that patients generally experienced considerably less postoperative pain following arthroscopic rather than conventional meniscectomy (Klein & Schulitz, 1983). In an article dealing with technique, problems, complications, and follow-up results of 100 arthroscopic meniscectomies (Klein & Schulitz, 1983), only 17 of the 102 patients in the study experienced mild pain on the first postoperative day. There was no information in the article about basic patient characteristics such as age and gender. Immediate postoperative management was not mentioned. The method used to measure pain was also not described. Reduction in postoperative pain was attributed to the small incisions made during arthroscopic surgery (Klein & Schulitz, 1983).

The efficacy of a non-steroidal anti-inflammatory drug (NSAID) on recovery following open partial meniscectomy was evaluated by Arvidsson & Eriksson in 1987. Patients were assigned to a NSAID or a placebo group. Knee pain, swelling, range of motion, strength, as well as patient tolerance of the medication was evaluated 1, 3, 7, 11, and 21 days postoperatively. Patients reported knee pain at

rest by using a graded 21 unit pain scale. The mean pain scores of patients in both groups, one day following surgery, were between 6 and 7. Mean pain scores of both groups dropped 3 days following surgery to 1.9 (NSAID) and 1.5 (placebo). No significant difference in pain scoring was found between the two groups.

A thorough search of the literature yielded only one study (Ogilvie-Harris et al., 1985), that included detailed information concerning the recovery of knee mobility following arthroscopic meniscectomy. Patients in the prostaglandin inhibitor group had significantly greater knee mobility than patients in the placebo group. Mean range of motion of patients in the prostaglandin inhibitor group 7 and 21 days postoperatively was 115 and 125 degrees compared to the placebo group's 102 and 118 degrees. Knee mobility of both groups was equal 42 days following surgery. There were no details in the study about how knee mobility was assessed and no indication if the values reported represented active or passive knee range measurements.

Following open partial meniscectomy, knee mobility was assessed and reported in two drug efficacy studies (Muckle, 1984; Arvidsson & Eriksson, 1987). In the first study, mobility was reported not in degrees of motion but on a 4-point scale. The first unit of the scale represented 0-25 degrees of motion. The fourth unit of the scale

represented motion greater than 75 degrees. The operated limb of all patients in the study was immobilized for 14 days following surgery. Knee flexion scores of all patients 14 days following surgery ranged between 50 and 75 degrees. Full knee flexion was recovered by partial meniscectomy patients in the prostaglandin inhibitor group 21 days following surgery while total meniscectomy patients in the same group took 28 days. In the analgesic group, partial meniscectomy patients recovered full knee flexion in 28 days, and total meniscectomy patients in 56 days following surgery.

In the second study (Arvidsson & Eriksson, 1987), active and passive knee range of motion was measured with a goniometer 1, 3, 7, 11, and 21 days following open partial meniscectomy. Knee mobility was expressed as a percentage of the patient's non-injured leg. The mean range of active and passive motion of the NSAID group exceeded that of the placebo group at all postoperative measurements. The difference was statistically significant on day 7. The percentage of active knee mobility of the NSAID group versus the placebo group at 7 days was 82% versus 65%, at 11 days - 85% versus 78%, and at 21 days - 95% versus 88%.

Studies designed primarily to evaluate the effectiveness of various postarthroscopic rehabilitation programs were uncommon in the literature. However, the impact of various rehabilitation programs on the subsequent

recovery of knee function following meniscectomy via open arthrotomy was considered by several authors (Forster & Frost, 1982; Gough, 1975; Jenkins, Imms, Prestidge, & Small, 1976; Leonard, 1975).

Relatively simple measures such as days to return to work (Gough, 1975), presence of residual knee symptoms 6 months following surgery (Leonard, 1975), and functional tests such as stair climbing (Forster & Frost, 1982) were used as criteria to determine "recovery". The impact of knee rehabilitation programs on early recovery (i.e. during the first few weeks) following surgery was not demonstrated.

In one study (Gough, 1975), two postmeniscectomy rehabilitation programs were compared. Patients in one group remained hospitalized and did leg exercises in bed for the first 10 postoperative days. Patients in the other group were not given exercise instructions. Instead, they were discharged home 1 or 2 days following surgery with their operated leg immobilized in a plaster cast for 10 days. Return to work was the sole criterion used to determine recovery. Patients in the plaster cast group returned to work 1 week earlier than the other patients. The author concluded that rest, not exercise, was indicated following meniscectomy.

In a randomised, controlled trial (Leonard, 1975), two postmeniscectomy regimes were compared to determine the

role of early weight bearing and ambulation. Results at 6 months showed no significant difference between the two groups in terms of number of days off work (53.5 vs. 51 days), time to achieve full knee mobility, (75 vs. 71 days), and presence of residual symptoms such as pain and effusion (23.4% vs. 15.2% of cases). The author concluded that early ambulation should be encouraged since it did not adversely affect the final result.

The cost-effectiveness of outpatient physiotherapy after medial meniscectomy was evaluated by Forster & Frost in 1975. In a randomised, controlled trial, the outcome of two groups of patients was compared. Both groups received the same inpatient physiotherapy that consisted of quadriceps strengthening exercises, and a home exercise program. One group of patients received out-patient physiotherapy, the other group did not. The out-patient physiotherapy regimen was not described. Results at 26 weeks showed no significant difference in clinical outcome (i.e. quadriceps circumference and knee mobility), or in clinical qualitative variables such as effusion, and time to return to work. The authors concluded that out-patient physiotherapy following medial meniscectomy was not indicated or economically justified. Surprisingly, the authors recommended continued in-patient physiotherapy though they did not directly address that issue in the

study and offered no explanations to support their recommendation.

By and large, the results of early studies failed to justify the role of physiotherapy in the routine postoperative management of meniscectomy patients. The financial advantages of discontinuing apparently ineffective rehabilitation programs and returning patients to work promptly following surgery were considerable (Forster & Frost, 1982; Gough, 1975). In one study (Gough, 1975), the author calculated that shortening the duration of hospital stay following surgery by as much as 10 days could yield a significant amount of savings. In a second study (Forster & Frost, 1982), it was reported that the most economical way of returning men to work following meniscectomy was by eliminating routine outpatient physiotherapy.

Arthroscopic Surgery - Benefits and Role of Rehabilitation

The financial implications of arthroscopic surgery, compared to conventional open arthrotomy, in terms of decreased costs to the health-care system, and a more rapid return of the patient to work have been shown to be substantial (Jackson, 1983). The financial advantages of arthroscopic surgery were well recognized and frequently cited in the literature (Besser & Stahl, 1986; Guhl, 1979; Hershman & Nisonson, 1983; Klein & Schulitz, 1983).

Following arthroscopic surgery, the duration of hospital stay ranged from 3-5 days (Klein & Schulitz, 1983), 2 days (Hershman & Nisonson , 1983), to 1 hour (Besser & Stahl, 1986). In marked contrast, hospital stays of 10-15 days following meniscectomy via open arthrotomy were common (Gough, 1975; Leonard, 1975).

Among the many benefits attributed to arthroscopic surgery were rapid recovery (Grana et al., 1982; Rosenberg & Wong, 1982) and need for "minimal rehabilitation" (Besser & Stahl, 1986, p.297). When the sole criterion used to determine "recovery" was the number of days to return to work or sport following surgery, the impact of arthroscopic surgery was undeniable. Following arthroscopic meniscectomy, patients returned to work in 1 (Hershman & Nisonson, 1983) or 2 (Hamberg & Gillquist, 1984; Lysholm & Gillquist, 1981) weeks. Athletes of international caliber resumed full athletic training and competition in 2 weeks or less (Lysholm & Gillquist, 1983) while most patients resumed recreational activities within 4 weeks (Hamberg & Gillquist, 1984; Lysholm & Gillquist, 1981). In contrast, following open arthrotomy, patients returned to work in 6 to 8 weeks (Forster & Frost, 1982; Gough, 1975; Leonard, 1975).

The shortened recovery period following arthroscopic surgery was attributed to the "comparatively noninvasive" (Colville & Jackson, 1985, p.280) nature of the procedure.

Compared to conventional open arthrotomy techniques, arthroscopic surgery inflicted considerably less surgical damage to the skin, joint capsule, subcutaneous tissue, and synovium of the knee (Dandy, 1978; Zarins et al., 1985). Quadriceps inhibition following arthroscopic meniscectomy was also much less than after open meniscectomy (Hamberg et al., 1983). These factors help to explain the shortened recovery period that generally followed arthroscopic surgery.

Rehabilitation and Isokinetic Devices

The introduction of isokinetic training devices such as the Orthotron and Cybex II sparked renewed interest in knee rehabilitation following surgery (Sherman et al., 1982). These devices have been used for testing (Campbell & Glenn, 1979; Costill, Fink & Habansky, 1977; Hamberg et al., 1983), and training (Sherman et al., 1983) surgical knee patients. By using the Cybex II isokinetic dynamometer, significant degrees of postmeniscectomy muscle weakness, ranging between 10% (Campbell & Glenn, 1979) to 20% (Costill et al., 1977), previously undetected by conventional means such as manual muscle tests, were identified (Campbell & Glenn, 1979; Costill et al., 1977; Sherman et al., 1983; Arvidsson & Eriksson, 1987).

In the first study (Campbell & Glenn, 1979), thigh strength of the rehabilitated knee, 5-15 months following

open meniscectomy, was compared to the normal knee. Eight subjects, four men and four women, ranging in age from 18-50 years, participated in the study. All subjects had been exposed to a rehabilitaion program that emphasized progressive resistive exercises. The rehabilitation program was not described. Knee extension and flexion torque was measured on the Cybex II at three velocities, 0 (isometric), 60, and 210 degrees per second. Each subject performed 3 sets of 10 reciprocal contractions of the knee extensors and flexors at 60 and 210 degrees per second. Average torque was calculated. Mean extensor and flexor torque of the rehabilitated postmeniscectomy knee was 10-12% less than the normal knee for all of the conditions tested. A significant difference between means of the rehabilitated and the normal knee was found at 210 degrees per second for knee extension, flexion and isometric flexion. The results of high velocity isokinetic testing indicated that the presumed "rehabilitated" knee had not fully recovered normal function.

In the second study (Costill et al., 1977), two postmeniscectomy rehabilitation programs were evaluated. The 18 men participating in the study were divided into two groups. Both groups followed a similar progressive strength training program for 6 weeks. One group supplemented the strength training program with a muscular endurance program. Maximal knee extensor strength was

measured in two ways, using a variably weighted bar, and with an isokinetic leg press. The leg press used was not described in the study. Subjects were required to perform a single maximal knee extension and a single leg press. When tested using the variably weighted bar, all subjects appeared to have recovered normal knee extensor strength. The results of the leg press test, however, indicated that the surgically treated leg of all the subjects was 20% weaker than the normal leg.

Two postmeniscectomy rehabilitation programs (i.e. a "conservative" and a "progressive" program) were evaluated in the third study (Sherman et al., 1983). Following open meniscectomy, 10 subjects participated in the conservative program that included a 2 week period of knee immobilization, a progressive weight lifting program, and an isokinetic program done on an Orthotron. Isokinetic muscular strength was assessed every 2 weeks at velocities of 60, 120, 180, 240, and 300 degrees per second, using a Cybex II isokinetic dynamometer. Strength was defined as the peak torque of at least three contractions at each velocity tested. Results were expressed as percent recovery of the operated leg compared to the normal leg. Subjects recovered 85% strength of the knee extensors after 14 weeks of training and 100% after 24 weeks of training. Only 4 subjects followed the progressive rehabilitation program. Subjects in this group followed a slightly

accelerated version of the conservative program. The operated knee of subjects in this group was not immobilized following surgery. In contrast to the results of the conservative group, subjects in the progressive group were fully recovered after only 6 weeks of training. There was no control group included in this study.

In the fourth study (Arvidsson & Eriksson, 1987), quadriceps torque of two groups of patients, namely a NSAID and a placebo group was reported. Torque was measured 3, 7, 11, and 21 days following open partial meniscectomy at 30, 120, and 240 degrees per second on an isokinetic device. The mean torque of at least three maximal voluntary efforts was calculated. Postoperative peak torque values were expressed as a percentage of the preoperative values of the injured and uninjured legs. The quadriceps torque of the NSAID group exceeded the placebo group at all three angular velocities, at all test occasions when torque was compared with the preoperative values of the injured and with the uninjured leg.

The effect of meniscectomy via open arthrotomy and via closed arthroscopic techniques on isokinetic muscle strength was also examined (Hamberg et al., 1983; Prietto et al., 1983). In the first study (Hamberg et al., 1983), muscle strength of patients who underwent diagnostic arthroscopy, arthroscopic surgery, or open meniscectomy was evaluated. Thirty-seven patients, 18-54 years of age,

participated in this study. Patients were assigned to 1 of 5 groups according to the type of surgery they underwent. The number of patients in each group ranged between 5 and 11. Thigh strength was measured using a Cybex II isokinetic dynamometer preoperatively and 1, 4, and 8 weeks following surgery. Torque was measured at two angular velocities, 30 and 180 degrees per second. Peak torque of three maximal contractions was determined. Postoperative measurements were expressed as percentages of the preoperative value of the injured leg. The results of the study indicated that meniscectomy impaired primarily quadriceps not hamstring strength. Diagnostic arthroscopy had no significant effect on thigh muscle strength. Patients who underwent arthroscopic surgery for a bucket-handle tear had an insignificant decrease of quadriceps strength 1 week after surgery that resolved by 4 weeks. Patients who underwent either arthroscopic partial meniscectomy for a flap tear or arthroscopic total meniscectomy, demonstrated a 40% reduction of quadriceps strength at 1 week but recovered fully in 8 weeks. Open meniscectomy patients had a 70% reduction of quadriceps strength at 1 week and were not fully recovered 8 weeks following surgery. The authors attributed the slow progress of the open meniscectomy patients to the considerable soft tissue trauma associated with the surgical procedure.

In the second study (Prietto et al., 1983), the effect of closed and open partial meniscectomies on knee extensor strength was compared. Twenty-two subjects, one group of normals and two groups of patients who underwent either closed or open partial meniscectomy were included in the study. Strength was measured prior to surgery, 20, and 42 days post surgery. Subjects were tested at five angular velocities (0, 48, 96, 144, & 192 degrees/s) using a Cybex II isokinetic dynamometer. Maximal knee extension torques were recorded at a specific joint angle (30 degrees below the horizontal plane) for all test velocities. Both groups of patients, 20 days postsurgery, had speed-specific impairment with greater deficits at the faster test speeds. The open meniscectomy patients were significantly weaker than the closed meniscectomy patients at all test velocities 20 days postsurgery. At 42 days, both groups exhibited similar degrees of impairment.

Thigh muscle weakness following arthroscopic procedures was also reported in a number of studies (Hamberg & Gillquist, 1984; Kovaleski et al., 1988; Mariani, Ferretti, Gigli, & Puddu, 1987; Morrissey, 1987; Patel et al., 1982). Unfortunately, differences between the various studies, in terms of subject inclusion criteria, postoperative treatment, testing conditions, and the methods used to express the results, preclude direct comparisons of the findings.

In the first study (Hamberg & Gillquist, 1984), thigh muscle strength was measured 10 months after arthroscopic meniscectomy. Isokinetic strength was measured with a Cybex II isokinetic dynamometer at 30 degrees per second. Persistent thigh muscle weakness was noted in patients having degenerative joint changes or anterior cruciate instability of the injured knee.

In the second study (Kovaleski et al., 1988), strength of patients who followed the same isokinetic rehabilitation program, and who were assigned according to age to 1 of 3 groups, was measured weekly, with a Cybex II isokinetic dynamometer, at velocities of 60, 120, 180, 240, and 300 degrees per second. The highest peak torque produced following at least three maximal reciprocal contractions of the quadriceps and hamstring muscles was recorded. There was no significant difference in the time it took each of the three groups to recover 85% strength of the normal leg. The time range was 2.9 to 3.4 weeks. All patients recovered almost 90% strength by 3.4 weeks of rehabilitation.

Mariani et al. (1987), measured strength of patients following arthroscopic meniscectomy for medial bucket-handle meniscal tears. Isokinetic testing using a Cybex II isokinetic dynamometer was performed preoperatively, 14, and 28 days postoperatively, at two velocities, 60 and 180 degrees per second. Results were expressed as percentages of the ipsilateral preoperative values. Fourteen days

following surgery, average recovery exceeded 90% of the preoperative values. Strength was fully recovered at 28 days.

In the fourth study (Morrissey, 1987), thigh strength of 19 male patients, 17-61 years of age was evaluated 5 months following arthroscopic partial meniscectomy. Testing was done using a Cybex II isokinetic dynamometer at 120, 180, and 240 degrees per second. All patients attempted 1 set of 4 maximal contractions at each test speed. Mean quadriceps peak torque of the injured knee, from the lowest to the highest speed was 106, 92, and 78 foot-pounds respectively.

In the final study (Patel et al., 1982), thigh strength of 16 patients, 16-67 years, who underwent arthroscopic meniscectomy for treatment of a bucket-handle, horizontal, or a complex tear was measured. Six weeks following surgery, Cybex II testing revealed quadriceps deficits of the injured leg compared to the normal leg of 16% at 30 degrees per second and 9% at 180 degrees per second.

Summary

In summary, the role of rehabilitation following arthroscopic meniscectomy has not been conclusively determined. There were very few studies in the literature that specifically evaluated the effect of rehabilitation on

knee recovery. Although the long-term effects of arthroscopic meniscectomy on knee function have been identified, less is known about the progression of early recovery (i.e. within the first few weeks) following surgery. Furthermore, the effect of physiotherapy intervention on early knee recovery has not been demonstrated.

III. METHOD

Subjects

Twenty subjects, 16 men and 4 women, with a preoperative clinical diagnosis of a suspected meniscal tear participated in this study. The subjects' ages ranged between 17 and 54 years. Subjects underwent arthroscopic surgery performed by one of five surgeons at the University of Alberta Hospitals between April and September 1989. Subjects excluded from participating in this study:

(1). Had a history of previous surgery of the affected knee (Ferkel et al., 1985; Northmore-Ball et al., 1983).

(2). Were unable to follow or read and understand simple verbal and written instructions in English.

(3). Lived outside of the Edmonton, Alberta area.

Subjects who satisfied the criteria were approached to participate in the study. All subjects who agreed to participate were requested to sign an informed consent form (Appendix B). Prior to surgery, subjects were matched for gender, age (within five years) and activity level (Lysholm & Gillquist, 1983) and were randomly assigned to either the treatment or the control group. Subjects were admitted into the study between April and September 1989. The first subject was randomly assigned to the treatment or the

control group. The age, gender, and activity level of the second subject was considered. If the second subject matched the first subject, he or she was assigned to the group opposite that of the first subject. If the second subject did not match the first subject, he or she was randomly assigned to the treatment or the control group. This process was repeated as subsequent subjects became available to participate in the study and continued until 10 matched pairs of subjects were formed.

Operative procedure

Arthroscopic partial meniscectomy was performed on 18 of the subjects. Diagnostic arthroscopy on the remaining 2 subjects revealed normal menisci. Of the two subjects with normal menisci, one was in the treatment and the other, the control group. The operation was performed in the day surgery clinic as an outpatient procedure. All five surgeons involved in the study used basically the same operative procedure. A general anaesthetic and a tourniquet were used. The arthroscope was introduced through an anterolateral joint line portal. Instruments were introduced through an anteromedial joint line portal. One or two additional portals, located just medial or lateral to the patellar tendon, were utilized as necessary. The knee joint was irrigated with normal saline. Following the surgery, which took approximately 30 minutes, a

dressing consisting of telfa, gauze, and tensors was applied to the knee. Sutures were removed approximately seven days after surgery.

Preoperative treatment

Prior to surgery, subjects in the treatment group were visited by a physiotherapist for approximately 15-30 minutes. In an attempt to standardize physiotherapy intervention, one therapist saw all subjects in the treatment group. A standard sheet of instructions about basic knee care and simple exercises was given to each subject (Appendix A). The physiotherapist explained the information on the sheet, ensured that the subject could perform the exercises correctly, and addressed any questions the subject had about his or her rehabilitation program.

Subjects in the control group were not visited by a physiotherapist prior to surgery. Instead, they received, from a registered nurse, a copy of the same knee instruction/exercise sheet given to subjects in the treatment group. Nurses participating in this study were trained to simply hand patients a copy of the instruction /exercise sheet and say, "Here is a pamphlet to read". The nurses did not offer any explicit instructions or clarifications about the information on the sheet. Subjects requesting additional information were advised to

contact the principal investigator of this study. However, not one subject did so.

Postoperative treatment

All subjects were offered crutches and were advised to progress weight bearing on the affected leg as tolerated. Tylenol No. 3® [4] (acetaminophen with codeine), an analgesic, was prescribed by all surgeons to relieve knee discomfort.

Testing

Knee pain, active range of motion, and knee extensor muscle strength of all subjects was evaluated on three separate occasions scheduled 1, 2, and 3 weeks following surgery. A second trained physiotherapist, who was not blinded to the group allocations of the subjects in the study, assessed all subjects.

Pain

Pain was measured using a visual analogue scale. The visual analogue scale used was a horizontal line, 100 mm in length (Appendix C). The extreme limits of the line were marked by perpendicular lines and anchored with the words "no pain" and "worst pain imaginable" at opposite ends of

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[4]Tylenol with Codeine No. 3, McNeil Pharmaceutical Ltd., Stouffville, Ontario

the scale. The subject was instructed to mark the line at a position between the two extremes of the scale that indicated the average level of pain intensity he or she had experienced, with regular activities of daily living, during the preceding 24 hours. The same sheet (Appendix C) was used for all 3 test sessions but the sheet was folded so the subject could not see his or her previous test marks. The distance from the "no pain" end to the point the subject marked on the scale was measured with a ruler in millimeters and that numerical value was recorded.

Visual analogue scales have been a popular and convenient way to quantify subjective pain intensity (Whitaker & Warfield, 1988). Visual analogue scale measurements of pain are regarded as reliable and valid (Chapman et al., 1985; Huskisson, 1974). Such scales have demonstrated sensitivity to small changes in pain intensity (Downie et al., 1978; Scott & Huskisson, 1976) and have shown the time course of the action of a treatment satisfactorily (Huskisson, 1974).

The total number of Tylenol No. 3 pills each subject consumed during the first three weeks following surgery was recorded. During each test session, subjects reported the number of Tylenol No. 3 pills they had consumed during the previous week. Subjects did not keep a daily log of their pill consumption.

Range of motion

Goniometry is a technique commonly practiced by physiotherapists. It is considered an acceptable method of objectively assessing limitation of joint mobility. Goniometric measurements of the knee joint are both reliable and valid (Gogia, Braatz, Rose, & Norton, 1987; Rothstein, Miller, & Roettger, 1983). Many investigations have demonstrated that intratester reliability, as is pertinent to this study, was higher than intertester reliability (Gajdosik & Bohannon, 1987).

Active knee mobility (Gajdosik & Bohannon, 1987) was measured with a large, clear plastic, universal TEC goniometer. Standardized testing procedures, as described by the American Academy of Orthopaedic Surgeons (1965) handbook were observed. Total excursion of active knee mobility (i.e. total degrees of motion from full knee extension to full flexion) was recorded. The reliability of the physiotherapist, to measure knee range of motion of 11 able-bodied individuals (7 women, 4 men), was tested prior to this study (Appendix D).

Strength

Strength of the knee extensor muscles was measured objectively using a Cybex II isokinetic dynamometer. This dynamometer is an exercise and testing device that can measure both static and dynamic torque (Patel et al.,

1982). It is the most commonly used instrument to clinically measure muscular performance (Mayhew & Rothstein, 1985).

High reliability of the measurement of knee extensor peak torque of an able-bodied population has been reported (Johnson & Siegel, 1978). Stability of Cybex II measurements over a period of time has been demonstrated (Mawdsley & Knapik, 1982). The validity of Cybex II for measuring weights, the narrowest interpretation of validity, has also been established (Mayhew & Rothstein, 1985).

The isokinetic apparatus was checked and calibrated daily according to the procedures recommended by the Cybex manufacturer (Appendix E). A damp setting of 2 and a paper speed of 5 mm per second were used for testing. The subject was positioned on the stabilization chair with hip flexion of 105-110 degrees (Bohannon, Gajdosik, & LeVeau, 1986; Felder 1978) and knee flexion of 90 degrees or as close to 90 degrees as the subject could tolerate. The input axis of the dynamometer was visually aligned with the lateral femoral epicondyle. The lever arm pad was strapped to the lower leg just proximal to the malleoli. Stabilization straps were secured across the subject's chest, pelvis, and thigh (Mendler 1967). During testing, the subject was permitted to grip the sides of the table or the handles of the stabilization chair with both hands.

The unaffected leg was tested first to familiarize subjects with the Cybex II isokinetic device. The subject was allowed a warm-up of 4-6 submaximal knee extensor contractions at 105 degrees per second. This velocity was selected because it was between the test velocities used in the study. Each subject performed 3-5 submaximal concentric contractions of the knee extensors at both test speeds used in this study (i.e. 60 & 240 degrees/s) before actual testing commenced. Each subject was given identical, standardized instructions prior to strength testing. The subjects were instructed to kick their leg up as hard and as fast as they could. Subjects were verbally encouraged during the test and received immediate visual feedback about their performance by watching the voltmeter gauge.

The actual test consisted of two sets of 3 concentric maximal contractions of the knee extensor muscles. One set was at a velocity of 60 degrees per second and the second set at a velocity of 240 degrees per second. The order of testing at the two velocities was randomized by subject draw to minimize possible variability due to learning or fatigue (Wyatt & Edwards, 1981). There was a one minute rest period between each contraction, and a three minute rest between each set to allow time for repletion of muscular phosphocreatine concentrations.

These velocities (i.e. 60 & 240 degrees/s) have been used in previous studies (Campbell & Glenn, 1979; Kovaleski et al., 1988; Mariani et al., 1987; Morrissey, 1987; Wyatt & Edwards, 1981). It has been reported (Wyatt & Edwards, 1981), that for normal adults during free cadence gait (velocity = 133 cm/s), the knee extends at a velocity of 233 degrees per second during the terminal swing phase of the gait cycle. In the present study, a "functional velocity" of 240 degrees per second was selected as well as a more conventional isokinetic test velocity of 60 degrees per second.

Torque output was recorded in foot-pounds (ft-lbs). For the purpose of this study, peak torque of three contractions performed at each velocity tested was measured, and the average peak torque was calculated. The reliability of the physiotherapist, to measure peak torque, of three able-bodied women, was tested prior to this study (Appendix D). The average peak was used in the statistical analysis of the results. Strength of knee extensor muscles was expressed in terms of average peak torque. Peak torque is "the most commonly used parameter in isokinetic testing" (Morrissey, 1987, p.405). In previous studies, (Mawdsley & Knapik, 1982; Murray, Gardner, Mollinger, & Sepic, 1980; Prietto et al., 1983; Scudder, 1980), peak torque was used as a measure of strength. This variable has been

considered to be a valid indicator of the quadriceps muscle to generate torque (Morrissey, 1987).

At the final test session, subjects completed a short evaluation form concerning the study. Included in the evaluation form were questions about the type, frequency and duration of any physical activities subjects engaged in during the study (Appendix F).

Statistical analysis

Descriptive statistics of the ages and Tylenol No. 3 pill taking behaviour of the treatment and control groups were determined. As well, the age and pill taking behaviour of the two groups were compared using t-tests. Pain and knee mobility were each analysed separately using two-way analyses of variance with repeated measures (Group x Time). Knee extensor muscle strength was evaluated using a three-way ANOVA with repeated measures on 2 factors (Group x Velocity x Time). Significant effects were analyzed using the Newman-Keuls method of multiple comparisons.

In an attempt to explain the results of this study, Chi-square was used to examine differences between groups in response to each question.

All statistical tests were evaluated at the $p < .05$ level of significance.

IV. RESULTS

The purpose of this study was to determine if physiotherapy intervention prior to arthroscopic knee surgery had a measurable effect on early knee recovery. It was hypothesized that subjects who received standard instructions about basic knee care and simple exercises from a physiotherapist, prior to undergoing arthroscopic surgery, would have less pain, greater knee mobility, and greater knee extensor muscle strength during the first three weeks following surgery, than subjects who were not seen by a physiotherapist.

The results are arranged in the following five segments:

(1). Subjects.

(2). Pain.

(3). Range of motion.

(4). Knee extensor muscle strength.

(5). Evaluation form.

Subjects

Twenty subjects participated in the study. There were 8 men and 2 women in both the treatment and control groups. The mean age of subjects in the treatment group was 29 years (SD = 11.8, range 17-53). The mean age of subjects in the control group was 33.3 years (SD = 10.8,

range 17-51). The age difference between the two groups was not significant, t (18) = .846, p = .40.

Pain

Following arthroscopic knee surgery, subjects received a prescription for Tylenol No. 3, an analgesic medication. Descriptive statistics concerning the self-reported total number of Tylenol No. 3 pills subjects consumed during the first three weeks following surgery is presented in Table 1. The groups were not significantly different with respect to the total number of Tylenol No. 3 pills consumed, t (18) = .42, p = .68.

Table 1

The Mean, Standard Deviation, and Range of Tylenol No. 3 Pills Consumed by all Subjects During the First Three Weeks Following Arthroscopic Surgery

	Pills Consumed		
Group	M	SD	Range
Treatment	2.8	3.5	0 - 12
Control	3.4	2.7	0 - 8

M = Mean Number of Pills SD = Standard Deviation

Pain intensity of both groups, reported during the first three weeks following surgery, is presented in Table 2. The analysis of variance revealed a significant Group x Time interaction effect (Appendix H). Only one significant pair, between Time 2 and Time 3 of the control group, was identified by the post hoc analysis (Appendix I).

Table 2

Mean Pain Intensity Measured On the Visual Analogue Scale During the First Three Weeks Following Arthroscopic Surgery

		Time (weeks)		
Group		1	2	3
Treatment	M (mm)	12.2	11.0	15.4
	SD	9.6	12.3	15.0
Control	M (mm)	19.8	23.3	7.3*
	SD	14.2	22.6	6.8

M = Mean Pain SD = Standard Deviation

* significantly different from Control group at Time 2

Range of Motion

The total degrees of active knee range of motion of both groups, measured during the first three weeks following surgery, are presented in Table 3. The analysis of variance demonstrated a significant time effect only (Appendix H). Significant differences were between Time 1

and Time 2 and between Time 1 and Time 3 (Appendix I, Table 3).

Table 3

Mean Degrees of Total Active Knee Range of Motion Measured During the First Three Weeks Following Arthroscopic Surgery

		Time (weeks)		
Group		1	2	3
Treatment	M (deg)	124.1	133.0	137.8*
	SD	10.2	6.2	4.3
Control	M (deg)	108.3*	126.6+	133.9+
	SD	24.2	11.7	5.5

M = Mean Range of Motion SD = Standard Deviation

* significantly different from Treatment Group at Time 1

+ significantly different from Control Group at Time 1

Strength of the Knee Extensor Muscles

Strength values of both groups, measured during the first three weeks following surgery, are presented in Table 4. The ANOVA results indicated that there were significant time and velocity effects but no significant group effect or three-way interactions (Appendix H). Post hoc analysis of the time and velocity effects identified the significant pairs (Appendix I).

As was expected, peak torque generated at 60 degrees per second was significantly different from peak torque generated at 240 degrees per second during all three test sessions. At velocities of 60 and 240 degrees per second, significant differences were noted between Time 1 and Time 2 and between Time 1 and Time 3 for both groups.

Evaluation form

The percentage of group responses to questions on the evaluation form are presented in Appendix J. One hundred percent of subjects in both groups indicated that they read the knee instruction/exercise sheet (Appendix J). The majority of subjects indicated that they understood "most of" the information contained in the sheet. The percentage of subjects in the two groups who reported to do what the instruction/exercise sheet said was not the same (Appendix J, question # 3.). Chi-square analysis revealed that the difference was not significant. Only control group subjects reported to use other modalities such as heat to minimize knee discomfort but Chi-square analysis indicated that this difference between the two groups was not significant.

Table 4

Mean Knee Extensor Muscle Torque at 60 & 240 degrees/s Measured During the First Three Weeks Following Arthroscopic Surgery

Group		Time (weeks) 1	2	3
Treatment	60 degrees/s			
	M (ft-lb)	88.9	106.2#	114.6#
	SD	45.3	41.0	39.6
	240 degrees/s			
	M (ft-lb)	48.6*	62.1*#	61.4*#
	SD	25.2	24.2	20.7
Control	60 degrees/s			
	M (ft-lb)	81.9	99.0!	104.6!
	SD	34.6	36.5	35.6
	240 degree/s			
	M (ft-lb)	42.3+	54.3+!	62.0+!
	SD	21.8	20.1	21.5

M = Mean Knee Extensor Muscle Torque

SD = Standard Deviation

* significantly different from Treatment Group peak torque (60 degrees/s) at all Times

+ significantly different from Control Group peak torque (60 degrees/s) at all Times

significantly different from Treatment Group at Time 1

! significantly different from Control Group at Time 1

Over 60% of subjects in both groups engaged in physical activities such as walking or swimming during the first week following surgery. By the third week following surgery, the figure rose to over 90%. Chi-square analysis comparing the two groups on participation in physical activities was not significant. The activities subjects reported to have participated in following surgery varied and ranged from walking, to cycling, swimming, golfing, and weight-lifting. Over 60% of subjects in both groups reported that their involvement in the study alone had not affected the way they looked after their knee following surgery. In contrast, more than 85% of subjects in the treatment group indicated that the visit by the physiotherapist prior to surgery had influenced the way they looked after their knee following surgery.

V. DISCUSSION

The purpose of this study was to determine if physiotherapy intervention prior to arthroscopic knee surgery had a measurable effect on early knee recovery. Two groups participated in this study. Subjects in only one of the two groups were seen by a physiotherapist prior to surgery. One, 2, and 3 weeks following surgery knee pain, range of motion, and knee extensor muscle strength of all subjects was assessed. The treatment and control groups were compared on each of the three variables (i.e. pain, range of motion, and knee extensor muscle strength). The discussion is organized into the following sections:

(1). Pain.

(2). Range of motion.

(3). Knee extensor muscle strength.

(4). Clinical significance.

Pain

It was hypothesized that subjects who were seen by a physiotherapist prior to undergoing arthroscopic knee surgery would have less pain during the first three weeks following surgery than subjects who were not seen by a physiotherapist. The results of the present study did not support the hypothesis.

Plausible explanations for the significant Group x Time interaction were not readily evident. Possible differences in the analgesic medication consumption of the two groups, adherence to the information contained in the instruction/exercise sheet, and the types of physical activities subjects participated in following surgery were considered.

The analgesic pill taking behaviour of subjects in both groups was similar. There was no significant difference between the two groups in terms of the total number of analgesic pills consumed following surgery. All subjects in both groups reported that they consumed analgesic medication only during the first postoperative week.

Results of the evaluation form suggested that comprehension of the instruction/exercise sheet and adherence to the information contained in the sheet were essentially the same for both groups. The percentage of subjects in the two groups who engaged in physical activities following surgery, and the nature of those activities, were also not significantly different.

One can speculate that the patterns of pain intensity of the two groups in the present study were due, in part, to the physiotherapy intervention. Though not directly tested in this study, it is conceivable that subjects in the treatment group were generally more wary about taking

care of their knees following surgery than subjects in the control group. Perhaps, the treatment group subjects did not impose undue demands on their knees. Control group subjects may have attempted to do too much, too soon following surgery and consequently experienced more pain than treatment group subjects during Time 1 and Time 2. Pain may have been the impetus that prompted control group subjects to dramatically reduce the demands they made on their knees and consequently, their pain subsided by Time 3.

In the present study, subjects in both groups reported relatively low levels of pain following arthroscopic surgery. This finding was consistent with that of previous studies (Fulkerson & Folcik, 1986; Indelicato, 1986; Ogilvie-Harris et al., 1985). Fulkerson and Folcik (1986), stated that oral analgesics were frequently needed during the first four days following arthroscopic surgery to alleviate the significant but short-term pain associated with arthroscopic procedures. In the present study, the first measure of pain intensity was taken seven days following surgery. It is conceivable that during the acute postoperative period (i.e. first few days following surgery), there was a greater difference in mean pain intensity between the treatment and control groups than the difference measured seven days following surgery. In the present study, a significant difference in pain levels

between the treatment and control groups during the first few days following surgery possibly went unnoticed because of the design of the study.

Indelicato (1986), reported that 100% of the 38 subjects in his study had "no pain" five days following arthroscopic surgery. In the study, pain was measured using a four-point scale that ranged from "no pain" to "severe pain". No distinctions were made in the study between pain at rest, or pain with activities. In the present study, the more sensitive visual analogue scale (Huskisson, 1974) was used to measure the pain experienced by subjects with regular activities of daily living.

In a postarthroscopic meniscectomy follow-up study conducted by Ogilvie-Harris et al., (1985), a distinction was made between the presence of pain at rest, with normal activities, and with increased activities. Pain was not quantified. The percentages of patients free of pain with normal activities during the first three weeks following surgery was 35%, 40%, and 50% respectively. In the present study, using the more sensitive visual analogue scale, subjects in both the treatment and control groups reported persistent low levels of pain with regular activities, during the first three weeks following surgery.

Range of Motion

It was hypothesized that subjects who were seen by a physiotherapist prior to undergoing arthroscopic surgery would have greater knee range of motion during the first three weeks following surgery than subjects who were not seen by a physiotherapist. This hypothesis was rejected in the present study. The group effect ($p = .06$) approached, but did not reach the level of significance selected for this study (i.e. $p = .05$). A significant group effect might have been attained with an increase in the sample size of the present study.

The physiotherapy intervention might have contributed to the difference between groups at Time 1. During the acute postoperative period (i.e. first few days following surgery), treatment group subjects may have avoided unduly stressing their knees resulting in less initial pain and swelling. Compared to the control group subjects, treatment group subjects would likely regain knee mobility more rapidly because they had less pain and swelling.

Arvidsson and Eriksson (1987), reported that the greatest restriction of active knee range of motion following open partial menisectomy was within the first 6 days. By day 7, patients regained 80% of normal range. In the present study, 7 days following arthroscopic menisectomy, subjects similarly regained approximately 77% - 88% of predicted normal knee range of motion reported in

the literature (American Academy of Orthopaedic Surgeons, 1965). The first measure of knee range of motion in the present study was made 7 days following surgery. Differences in range of motion that may have existed between the groups, during the first few days following surgery, would not be detected because of the design of the study.

As expected, range of motion of both groups increased during the 3 weeks of the study (Table 3). With the passing of time, normal healing progressed, and joint range of motion improved. For the treatment and control groups the difference was significant between Time 1 and Time 3. For the control group alone, a significant difference was noted between Time 1 and Time 2. The differences might simply have reflected the varying rates of recovery of subjects in both groups.

The mean ranges of motion at Time 1 and Time 3 in the present study (Table 3) exceeded those of a previous study (Ogilvie-Harris et al., 1985). The mean range of motion of all patients in the 1985 study, 7 and 21 days following arthroscopic menisectomy was 109 and 122 degrees. In that study, however, the method used to measure and record range of motion was not described, nor was it clear if the values reported represented active or passive range of motion. In the present study, active knee range of motion was measured

with a goniometer and the values reported represent degrees of mean total active range of motion.

Knee Extensor Muscle Strength

It was hypothesized that those subjects seen by a physiotherapist prior to undergoing arthroscopic surgery would have greater knee extensor muscle strength than subjects who were not seen by a physiotherapist. This hypothesis was rejected in the present study (Appendix H).

A significant velocity effect was expected in the present study in which strength was measured at two velocities (i.e. 60 & 240 degrees/s). Subjects in the present study generated greater peak torque at 60 degrees per second than they did at 240 degrees per second during all three test sessions. The inverse relationship between torque output and velocity has been well documented in previous studies (Moffroid et al., 1969; Perrine & Edgerton, 1978; Thorstensson, Grimby, & Karlsson, 1976).

A significant time effect was also anticipated in the present study. As time progressed and natural healing occurred, a gradual increase in strength of subjects was expected. At velocities of both 60 and 240 degrees per second, strength of treatment and control group subjects increased significantly between Time 1 and Time 2 and between Time 1 and Time 3.

The significant difference in means at Time 1 and Time 2 may have reflected the rapid progress subjects made as they moved from the immediate postoperative period that was characterized by a fresh incision, soft tissue bleeding, pain and muscle inhibition (Zarins et al., 1985) to the early healing phase. Similarly, the differences noted between Time 1 and Time 3 may reflect the improvement in strength made from the immediate postoperative period to the later healing phase. Changes in strength between Time 2 (early healing phase) and Time 3 (late healing phase) were not as pronounced.

The means of the treatment group torques exceeded the means of the control group during all three test sessions, and at both velocities except at Time 3, 240 degrees per second (Table 4 & Table 5). Differences between the groups, were not significant. One might speculate that the physiotherapy intervention in the present study was inadequate and made no substantial impact on recovery of knee extensor muscle strength. Small sample size in the present study might also explain the non-significant group effect.

Recovery of knee extensor muscle strength following arthroscopic surgery has been investigated in a number of previous studies (Kovaleski et al., 1988; Mariani et al., 1987; Morrissey et al., 1987; Patel et al., 1982). However, differences in methodology between these studies

and the present study in sample composition, scheduling of testing, test velocities, and style of reporting the results preclude meaningful comparisons of the results of the present study with those of previous studies.

Mariani et al., (1987), measured knee extensor strength at 60 degrees per second, two weeks following arthroscopic meniscectomy. The mean torque values ranged between 102 and 142 foot-pounds and the standard deviations ranged between 23 and 29 foot-pounds. In comparison, mean torque values in the present study were slightly lower, ranging between 99.0 and 106.2 foot-pounds, and the standard deviations slightly higher, ranging between 36.5 and 41.0 foot-pounds. The sample in the study by Mariani et al. was comprised of men 20-25 years of age. In the present study the sample was considerably less homogeneous because the age range of subjects was much wider (i.e. 17-53 years), and women as well as men participated. In the present study however, subjects were matched for sex, and age (within five years) in an effort to ensure comparable groups.

The ranges of mean torque of subjects in the present study during Time 1 and Time 2 concurred with those reported by Kovaleski et al., (1988) whose subject sample, comprised of men and women ranging in age from 16-58 years, more closely resembled the subject sample of the present study.

Clinical Significance

The results of the present study indicated that the postoperative knee pain, active range of motion, and knee extensor muscle strength of subjects seen by a physiotherapist prior to undergoing arthroscopic meniscectomy, was not significantly different from that of subjects who were not seen by a physiotherapist. In the present study, all subjects received identical information (i.e. knee instruction/exercise sheet), only the manner in which the information was conveyed to subjects in the two groups differed.

The results of this study are not surprising when one considers the following:

(1). The information contained in the instruction /exercise sheet was basic, and largely self-explanatory.

(2). All subjects indicated that they read the instruction/exercise sheet, and the majority of subjects in both groups reported that they understood most of the information contained in it.

(3). The physiotherapy intervention was not extreme or dramatic but consisted of only one, short, preoperative visit by a physiotherapist who

reinforced the information contained in the instruction/exercise sheet.

(4). Sample size was small.

It would be a grave error to assume, based on the results of this single study alone, that physiotherapy has no justifiable place in the management of arthroscopic meniscectomy patients. The apparent willingness of subjects, in both groups, to read the instruction/exercise sheet and to follow the information contained in it, particularly during the first week following surgery (Appendix J), suggested that arthroscopic surgery patients were eager for information about knee care and exercise. Furthermore, the fact that the majority of treatment group subjects indicated that the visit by the physiotherapist influenced the way they looked after their knee following surgery, suggested that physiotherapy intervention was likely beneficial in ways not detected in the present study. One physiotherapy session might have no measurable effect on knee pain, range of motion, and knee extensor muscle strength but perhaps additional sessions might have an effect. Further studies must be conducted to evaluate the impact of various forms of physiotherapy intervention, including actual supervised therapy, on knee recovery following arthroscopic meniscectomy, and to better define the role of the physiotherapist in the rehabilitation of arthroscopic meniscectomy patients.

VI. CONCLUSIONS

The purpose of this study was to determine if physiotherapy intervention prior to arthroscopic knee surgery had a measurable effect on early knee recovery. It was hypothesized that subjects who received standard instructions about basic knee care and simple exercises from a physiotherapist, prior to undergoing arthroscopic surgery, would have less pain, greater knee mobility, and greater knee extensor muscle strength during the first three weeks following surgery, than subjects who were not seen by a physiotherapist.

Within the limitations of this study, the following conclusions were drawn:

(1). Pain intensity, during the first three weeks following arthroscopic meniscectomy, of subjects who were seen by a physiotherapist, was not significantly less than the pain intensity of subjects who were not seen by a physiotherapist.

(2). Active knee range of motion, during the first three weeks following arthroscopic meniscectomy, of subjects who were seen by a physiotherapist, was not significantly greater than the active knee range of motion of subjects who were not seen by a physiotherapist.

(3). Active knee range of motion of all subjects increased significantly between the first and third week following surgery.

(4). Knee extensor muscle strength, measured at 60 and 240 degrees per second, on a Cybex II isokinetic dynamometer, during the first three weeks following arthroscopic meniscectomy, of subjects who were seen by a physiotherapist, was not significantly greater than the knee extensor strength of subjects who were not seen by a physiotherapist.

(6). Subjects generated greater knee extensor muscle torque at 60 degrees per second than at 240 degrees per second.

(7). All subjects read the knee instruction/exercise sheet.

(8). More than 85% of subjects who were seen by a physiotherapist prior to undergoing arthroscopic meniscectomy, indicated that the visit by the physiotherapist influenced the way they looked after their knee following surgery.

Recommendations

It is recommended that additional studies be conducted to determine the role of the physiotherapist in the rehabilitation of arthroscopic meniscectomy patients. For example:

(1). Larger samples of arthroscopic meniscectomy patients should be assessed.

(2). Patients should be examined 3-4 days following arthroscopic meniscectomy.

(3). The effectiveness of various knee instruction and exercise programs on knee recovery following arthroscopic meniscectomy should be evaluated.

(4). Outcome measures different from those used in the present study, such as knee swelling, or perfomance on specific functional tests should be used to assess knee recovery following arthroscopic meniscectomy.

(5). Knee recovery of arthroscopic meniscectomy patients who receive no instructions or exercises should be evaluated.

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APPENDIX A

KNEE INSTRUCTION/EXERCISE SHEET

KNEE INSTRUCTIONS & EXERCISES

After arthroscopic surgery your knee may likely feel swollen and uncomfortable. The swelling and discomfort may inhibit or weaken the ability of your muscles to perform their usual tasks. To reduce your knee swelling and discomfort and to improve the strength and mobility of your leg, do the following -

(1). apply ice to your knee before or after you exercise and whenever your knee is sore.

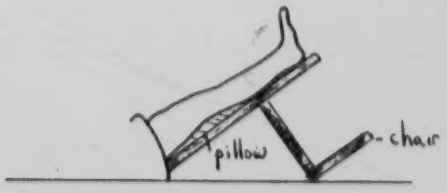
Ice is used to decrease pain and to reduce the heat and swelling in a joint. Movement of a joint is often easier after ice has been applied. When you apply ice to your knee, it will initially feel cold, then very cold, then somewhat painful, and finally numb. Leave the ice on for 15-20 minutes. Do not leave it on longer than this or it may have an opposite effect.

To make an ice pack, first soak a towel in cold water then wring it out. Place a few cups of crushed ice in the towel and fold in the sides of the towel so the ice is well contained. The ice pack can then be placed on your knee.

Instead of making an ice pack with crushed ice, a bag of frozen peas or corn can be used. Simply wrap the bag of peas or corn in a towel that has been soaked in cold water and wrung out. This is a quick and convenient method of preparing an ice pack.

To prevent water dripping from the ice pack onto the bed, place a plastic sheet or dry towel under your leg before applying the ice pack.

Elevate your injured leg so your foot is higher than your heart. In this way, gravity can help decrease the swelling in your knee while the ice pack is on. Elevate your leg on pillows or place a chair on the floor as displayed in the following diagram.



PLEASE NOTE:

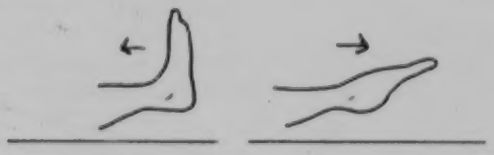
Some people are extremely sensitive to the application of ice to the skin and may experience severe discomfort. The skin of these people may become blotchy and red and remain so for a long period of time after the ice is removed. Such people should avoid using ice. If you experience these symptoms please stop applying ice to your knee and contact your physician or Lori Macdonald.

(2). Do the following exercises -

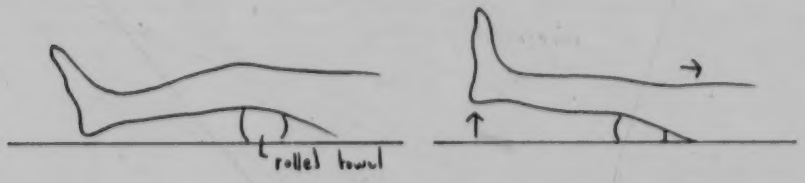
First Day

Do 1 set of 10 repetitions of each exercise at least four times during the day.

(a). Foot and Ankle - actively move your foot and toes up and then down.



(b). With your knee straight, tighten your thigh muscles so the back of your knee presses against the bed and your heel comes off the bed.

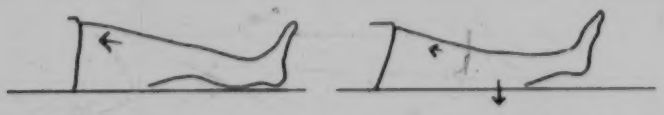


Second Day

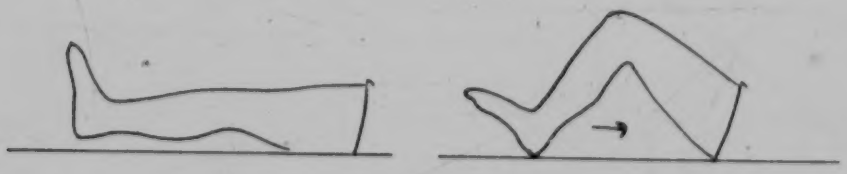
Start gradually by doing 1 set of 10 repetitions of each exercise 3 times a day. Progress to doing 3 sets of 10 repetitions of each exercise 3 times a day.

(a). Place a rolled towel or an object such as a large juice or coffee can under your thigh so that the perpendicular distance between the floor and the back of your knee measures between 3-4 inches. In

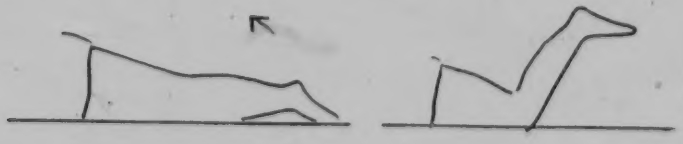
this position your knee will be bent slightly. Tighten your thigh muscles so the knee cap moves towards the body, the thigh muscles feel hard tothe touch, your heel lifts off the floor, and your leg straightens. Hold this position for 5-10 seconds, relax and then repeat this exercise.



(b). To improve your knee movement, lie on your back on the floor. By bending your hip and knee, slide your heel along the floor towards your bottom.

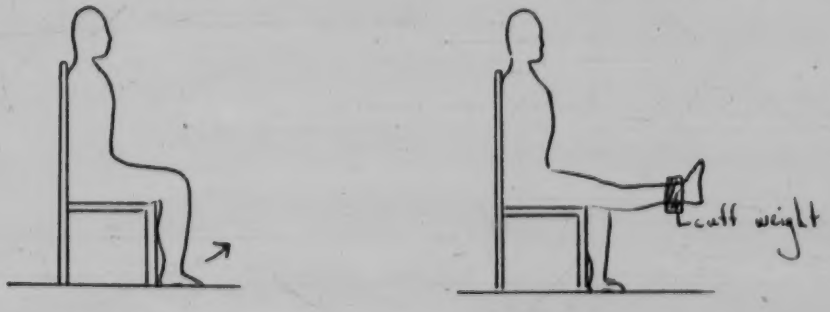


(c). To strengthen the muscles that bend your knee, lie on your front on the floor and bend your knee so your heel approaches your bottom.



(d). Sit up straight on a firm chair (e.g. kitchen chair). The seat of the chair should be long enough to support at least 3/4 of the length of your thighs. Slowly straighten your injured knee keeping your thigh on the chair. Maintain your knee in that straightened position for 5 seconds. Slowly lower your foot to the floor. Repeat.

If this exercise is too easy, add a weight. Wrap a cuff weight just above the ankle. If cuff weights are not available improvise by strapping a bag of sand or rice to your leg. Start with a weight of 1-2 pounds (i.e. approximately 0.5-1 kilogram). Additional weight may be added provided you can successfully complete 10 consecutive repetitions of this exercise and you do not experience significant, increased knee pain or swelling.



(3). Do not overdo it !! Listen to the signals your knee gives you and respond sensibly. Determine how much you can and cannot do by considering the amount of knee swelling and pain you have. If your knee becomes more swollen or painful and the pain persists for longer than a few minutes after the activity is over, reduce or stop participating in that particular activity.

APPENDIX B

LETTER OF INFORMATION

AND

CONSENT FORM

TITLE OF RESEARCH PROJECT:

Effect of Physiotherapy Intervention on Early Knee Recovery Following Arthroscopic Partial Meniscectomy

INVESTIGATORS:

Dr. D.W.C. Johnston, Associate Clinical Professor, Department of Surgery

Dr. D.J. Magee, Chairman, Department of Physical Therapy

Lori Macdonald, Graduate Student, Department of Physical Therapy

LETTER OF INFORMATION

Removal of torn cartilege in the knee is a very common surgical procedure. The main purpose of this study is to evaluate early knee recovery following arthroscopic removal of torn cartilege in the knee joint. You will be randomly assigned to one of two groups. One, two, and three weeks following surgery you will participate in 3 test sessions. Each test session will last approximately half an hour.

During each test session a physiotherapist will examine your knee. The examination will include measures to assess your knee pain, motion and strength. You will indicate your intensity of knee pain by marking a line graph. The physiotherapist will measure your knee motion using a goniometer, an instrument similar to a protractor. The strength of your thigh muscles will be tested on the Cybex II isokinetic apparatus. You will perform six contractions, straightening your leg, at each of two speeds preset on the Cybex II (a total of 12 contractions).

It is possible that you may feel some mild muscle soreness in your thighs following the Cybex II testing. The testing might also temporarily increase the discomfort in your knees. These possible side effects are expected to be minor in nature and last no longer than 3 days. If these side effects persist longer than 3 days please contact your surgeon's office or Lori Macdonald.

Your identity will remain confidential at all times throughout the study. Your name will not appear on any document or other information from us but you will be given a code number for record purposes. You are free to decline from participating in this study and may withdraw from the study at any time without jeopardy to your future care or treatment.

If you have any questions, please feel free to ask them.

TITLE OF RESEARCH PROJECT:

Effect of Physiotherapy Intervention on Early Knee Recovery Following Arthroscopic Partial Meniscectomy

INVESTIGATORS:

Dr. D.W.C. Johnston, Associate Clinical Professor, Department of Surgery

Dr. D.J. Magee, Chairman, Department of Physical Therapy

Lori Macdonald, Graduate Student, Department of Physical Therapy

CONSENT:

I acknowledge that the research procedures described on the attached letter of information and of which I have a copy, have been explained to me and that any questions that I have asked have been answered to my satisfaction. I have been informed of the alternatives to participation in this study. I also understand the benefits (if any) of joining the research study. The possible risks and discomforts have been explained to me. I know that I may ask now, or in the future, any questions I have about the study or the research procedures. I have been assured that personal records relating to these experimental protocols will be kept confidential and that no information will be released or printed that would disclose personal identity without my permission.

Name & Signature of Subject:_____

Name & Signature of Witness:_____

Date:_____

Signature of investigator:_____

The people who may be contacted about the research are:

Dr. D.W.C. Johnston - telephone no: 439-4945

Dr. D.J. Magee - telephone no: 492-5984

APPENDIX C

VISUAL ANALOGUE SCALE

Visual Analogue Scale

Mark a slash on the scale to indicate the intensity of knee pain you have experienced during the last 24 hours.

Test # 1

no pain ——————————————— worst pain imaginable

Test # 2

no pain ——————————————— worst pain imaginable

Test # 3

no pain ——————————————— worst pain imaginable

Note: The same sheet was used for all 3 tests but the sheet was folded so the subject could not see his or her previous test marks.

APPENDIX D

RELIABILITY OF RANGE OF MOTION AND CYBEX PEAK TORQUE

Range of Motion - Correlation of Reliability

Intra-rater reliability of goniometric measurements of active knee range of motion was calculated on 11 able-bodied subjects (7 women, 4 men). The Pearson product-moment and intraclass correlation coefficients were used to analyze the data. The intra-rater reliability (r = .99; ICC = .99) was high.

Cybex Peak Torque - Reliability

Intra-rater reliability of Cybex graph readings of 3 able-bodied women was determined. The results are presented in Table 1. The Interclass correlation coefficient (ICC = .99) was high.

Cybex Actual Peak Torque Measurements of Subjects Across Time

	Time		
Subject	1	2	3
1	123	123	123
2	94	94	94
3	73	72	73

Note: Peak torque measurements are in foot-pounds.

APPENDIX E

CYBEX CALIBRATION PROCEDURES

Cybex II Calibration Procedures

Turn the RDSC (Remote Digital Speed Control) speed selector ON. Press 60, then ENTER on the RDSC control. Move the input adapter back and forth being sure to meet resistance in both directions. Press 30, then ENTER on the RDSC.

A. Zero or null out recorder to resting signal of dynamometer, as follows:

1. Set DAMPING control at zero, CHART SPEED at 5MM/S with speed selector at 30 deg/s. Make sure there is no load on the dynamometer. Do this by removing any adapters from the dynamometer.

2. Set FT.LBS. SCALE on 180 and zero recorder stylus on baseline using ZERO ADJ. knob for Torque Channel.

3. Switch FT.LBS. SCALE to 30.

4. If stylus deflects from baseline, adjust ZERO NULL potentiometer on side of recorder with calibration screwdriver to zero stylus on chart baseline.

5. Repeat steps 2 through 4 until stylus deflects less than 1/2 minor division when switching back and forth between 180 and 30 FT.LBS. SCALES.

6. Set CHART SPEED at STANDBY.

B. Calibrate each Torque Range Scale as follows:

1. Set Torque Channel to FT.LBS. SCALE to be calibrated. Set DAMPING control at 3.

2. Press 30, then ENTER on the RDSC. Make sure there is no load on the dynamometer. Adjust stylus to zero baseline using Torque Channel ZERO ADJ. knob.

3. Insert T-bar calibration arm into long input adapter and set effective input arm length for FT.LBS. SCALE being calibrated (arm length B is used for the 180 FT.LBS. SCALE).

4. Add appropriate amount of disc weights for FT.LBS. SCALE being calibrated (32.5 lbs. for the 180 FT.LBS. SCALE). Cybex certified calibration weights, used in this study, are accurate to 0.01%.

5. Set CHART SPEED at 5MM/S.

6. Lift weighted T-bar calibration arm to vertical position above dynmometer. Pull or push weighted arm forward gently to engage isokinetic resistance before letting go so that arm falls smoothly until it contacts the floor.

7. Check the torque reading on the chart recording. The peak value for the 180 FT.LBS. SCALE setting should be five major divisions above baseline.

8. If the chart recording does not agree with the above value, adjust the potentiometer for the 180 FT.LBS. SCALE with the calibration screwdriver. Turning the potentiometer clockwise increases the torque reading, counterclockwise decreases it. The weight swing must be repeated each time an adjustment is made.

9. Once the torque value is correct, re-check twice to make sure reading is consistent.

10. Remove T-bar calibration arm from long input adapter.

(Calibration procedures taken from Cybex II Service and Parts Manual, Lumex, Ronkonkoma, New York, 1985)

APPENDIX F

EVALUATION FORM

Evaluation Form

Please read each question carefully and select the most appropriate response.

(1). Did you read the knee instruction/exercise sheet you were given? yes no

(2). Did you understand the instruction/exercise sheet?
most of it some of it none of it

(3). Did you do what the the instruction/exercise sheet said?

week 1	most of the time	some	none
week 2	most of the time	some	none
week 3	most of the time	some	none

(4). Did you apply ice to your knee more than 3 times per day?

week 1	yes	no
week 2	yes	no
week 3	yes	no

(5). Did you use anything else such as a heating pad or whirlpool to make your knee feel better?

yes no

If you selected "yes" please state what you used

_____ .

(6). Did you engage in any physical activities such as walking or swimming following surgery?

week 1 yes no

week 2 yes no

week 3 yes no

(7). If you selected a "yes" in question #6 list the activity or activities, the frequency (times per week), and the duration (minutes per day) of participation.

week	activity	frequency	duration

(8). Did your involvement in this study affect the way you looked after your knee following surgery?

yes no

Answer the next two questions only if you were seen by a physiotherapist prior to surgery.

(9). Did you understand the instructions the physiotherapist gave you?

most of them some none

(10). Did the visit by the physiotherapist affect the way you looked after your knee following surgery?

yes somewhat no

APPENDIX G

RAW DATA

FOR PAIN, RANGE OF MOTION, & STRENGTH

Raw data for pain measured in millimeters on the visual analogue scale (VAS) during the first three weeks following arthroscopic surgery

Subject	Group	VAS 1	VAS 2	VAS 3
1	T	5.5	4.0	50.0
2	T	2.0	1.0	13.0
3	T	14.5	1.5	20.5
4	T	9.0	27.0	23.5
5	T	10.5	9.0	12.0
6	T	16.0	7.5	1.0
7	T	37.0	38.5	23.5
8	T	10.5	9.0	0.0
9	T	8.0	2.0	2.0
10	T	9.0	10.5	9.0
11	C	8.5	8.0	4.5
12	C	16.0	1.0	0.0
13	C	29.0	37.0	4.0
14	C	26.0	26.2	11.0
15	C	11.5	75.0	21.0
16	C	16.0	9.0	5.5
17	C	43.0	31.5	12.0
18	C	0.0	0.0	0.0
19	C	8.0	13.5	2.0
20	C	40.0	32.0	13.0

Raw data for total active range of motion (ROM) measured in degrees during the 3 weeks of the study

Subject	Group	ROM 1	ROM 2	ROM 3
1	T	124.0	127.0	140.0
2	T	115.0	129.0	140.0
3	T	131.0	140.0	140.0
4	T	128.0	135.0	135.0
5	T	132.0	136.0	140.0
6	T	132.0	136.0	141.0
7	T	100.0	123.0	132.0
8	T	127.0	138.0	140.0
9	T	132.0	140.0	141.0
10	T	120.0	126.0	129.0
11	C	97.0	134.0	138.0
12	C	111.0	134.0	138.0
13	C	106.0	125.0	135.0
14	C	127.0	131.0	132.0
15	C	130.0	132.0	135.0
16	C	112.0	116.0	128.0
17	C	50.0	112.0	129.0
18	C	128.0	140.0	140.0
19	C	127.0	137.0	140.0
20	C	95.0	105.0	124.0

Strength - raw mean peak torque (PT) scores measured in foot-pounds on the Cybex II isokinetic apparatus at 60 degrees per second during the first three weeks following surgery

Subject	Group	PT 1	PT 2	PT 3
1	T	43.0	126.0	123.0
2	T	42.0	51.0	53.0
3	T	113.0	99.0	139.0
4	T	121.0	128.0	143.0
5	T	111.0	106.0	108.0
6	T	72.0	105.0	116.0
7	T	46.0	50.0	61.0
8	T	128.0	147.0	140.0
9	T	169.0	178.0	180.0
10	T	44.0	72.0	83.0
11	C	131.0	156.0	164.0
12	C	86.0	99.0	107.0
13	C	104.0	147.0	149.0
14	C	115.0	117.0	117.0
15	C	44.0	52.0	48.0
16	C	55.0	61.0	88.0
17	C	26.0	68.0	76.0
18	C	108.0	112.0	113.0
19	C	94.0	113.0	115.0
20	C	56.0	65.0	69.0

Strength - raw mean peak torque (PT) scores measured in foot-pounds on the Cybex II isokinetic apparatus at 240 degrees per second during the first three weeks following surgery

Subject	Group	PT 1	PT 2	PT 3
1	T	39.0	69.0	69.0
2	T	31.0	35.0	35.0
3	T	30.0	51.0	50.0
4	T	77.0	88.0	83.0
5	T	60.0	63.0	65.0
6	T	38.0	70.0	65.0
7	T	25.0	31.0	39.0
8	T	63.0	85.0	78.0
9	T	99.0	97.0	94.0
10	T	24.0	32.0	36.0
11	C	39.0	67.0	77.0
12	C	43.0	60.0	61.0
13	C	46.0	66.0	73.0
14	C	75.0	66.0	63.0
15	C	21.0	15.0	14.0
16	C	25.0	28.0	45.0
17	C	7.0	42.0	51.0
18	C	65.0	76.0	70.0
19	C	67.0	72.0	74.0
20	C	35.0	51.0	92.0

APPENDIX H

SUMMARIES OF ANALYSES OF VARIANCE
OF
PAIN, RANGE OF MOTION, AND STRENGTH

Summary of the Two-Way Analysis of Variance of Pain Showing a Statistically Significant Interaction Effect:

HIERARCHICAL SUMMARY TABLE OF F-RATIOS FOR: VAS1

TYPE	PART OF MODEL		SSH	SSE	MSH	MSE	F-RATIO	DFH	DFE	PROB
UNIV	GRAND MEAN		13222.44	6136.33	13222.44	340.91	38.79	1.0	18.0	0.708E-5
UNIV	GROUP		230.89	6136.33	230.89	340.91	0.68	1.0	18.0	0.42130
ERROR TERM: CASES(GROUP)										
UNIV	TIME		374.68	4906.41	187.34	136.29	1.37	2.0	36.0	0.26590
GREENHOUSE-GEISER ADJ:			EPSILON:	0.98	187.34	136.29	1.37	2.0	35.4	0.26595
UNIV	GROUP*TIME		1148.84	4906.41	574.47	136.29	4.22	2.0	36.0	0.02266
GREENHOUSE-GEISER ADJ:			EPSILON:	0.98	574.47	136.29	4.22	2.0	35.4	0.02335
UNIV	CASES(GROUP)	*	6136.33	4906.41	340.91	136.29	2.50	18.0	36.0	0.00942
UNIV	TIME*CASES(GROUP)	*	4906.41	****	136.29	****	****	36.0	****	****
ERROR TERM: TIME*CASES(GROUP)										

AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.

Summary of the Two-Way Analysis of Variance of Range of Motion Showing a Statistically Significant Time Effect:

HIERARCHICAL SUMMARY TABLE OF F-RATIOS FOR: ROM1

TYPE	PART OF MODEL		SSH	SSE	MSH	MSE	F-RATIO	DFH	DFE	PROB
UNIV	GRAND MEAN		972062.82	5214.83	972062.82	289.71	3355.26	1.0	18.0	.652E-21
UNIV	GROUP		1135.35	5214.83	1135.35	289.71	3.92	1.0	18.0	0.06325
ERROR TERM: CASES(GROUP)										
UNIV	TIME		4051.23	3033.07	2025.62	84.25	24.04	2.0	36.0	0.233E-6
GREENHOUSE-GEISER ADJ:			EPSILON:	0.58	2025.62	84.25	24.04	1.2	20.8	0.00004
UNIV	GROUP*TIME		393.70	3033.07	196.85	84.25	2.34	2.0	36.0	0.11116
GREENHOUSE-GEISER ADJ:			EPSILON:	0.58	196.85	84.25	2.34	1.2	20.8	0.13884
UNIV	CASES(GROUP)	*	5214.83	3033.07	289.71	84.25	3.44	18.0	36.0	0.00079
UNIV	TIME*CASES(GROUP)	*	3033.07	****	84.25	****	****	36.0	****	****
ERROR TERM: TIME*CASES(GROUP)										

AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.

Summary of the Three-Way Analysis of Variance of Strength Showing Statistically Significant Time and Velocity Effects:

HIERARCHICAL SUMMARY TABLE OF F-RATIOS FOR: SIX1

TYPE	PART OF MODEL	SSH	SSE	MSH	MSE	F-RATIO	DFH	DFE	PROB
UNIV	GRAND MEAN	714409.01	85577.42	714409.01	4754.30	150.27	1.0	18.0	0.357E-9
UNIV	GROUP	1184.41	85577.42	1184.41	4754.30	0.25	1.0	18.0	0.62374
ERROR TERM: CASES(GROUP)									
UNIV	TIME	8811.52	7292.93	4405.76	202.58	2 .75	2.0	36.0	0.641E-6
GREENHOUSE-GEISER ADJ:		EPSILON:	0.69	4405.76	202.58	21.75	1.4	24.8	0.00002
UNIV	GROUP*TIME	41.22	7292.93	20.61	202.58	0.10	2.0	36.0	0.90353
GREENHOUSE-GEISER ADJ:		EPSILON:	0.69	20.61	202.58	0.10	1.4	24.8	0.82953
ERROR TERM: TIME*CASES(GROUP)									
UNIV	VELOCITY	58300.21	13617.22	58300.21	756.51	77.06	1.0	18.0	0.637E-7
UNIV	GROUP*VELOCITY	95.41	13617.22	95.41	756.51	0.13	1.0	18.0	0.72662
ERROR TERM: VELOCITY*CASES(GROUP)									
UNIV	TIME*VELOCITY	317.52	2352.53	158.76	65.35	2.43	2.0	36.0	0.10240
GREENHOUSE-GEISER ADJ:		EPSILON:	0.90	158.76	65.35	2.43	1.8	32.6	0.10855
UNIV	GROUP*TIME*VELOCITY	187.62	2352.53	93.81	65.35	1.44	2.0	36.0	0.25129
GREENHOUSE-GEISER ADJ:		EPSILON:	0.90	93.81	65.35	1.44	1.8	32.6	0.25211
UNIV	CASES(GROUP)	* 85577.42	2352.53	4754.30	65.35	72.75	18.0	36.0	.627E-22
UNIV	TIME*CASES(GROUP)	* 7292.93	2352.53	202.58	65.35	3.10	36.0	36.0	0.00051
UNIV	VELOCITY*CASES(GROUP)	* 13617.22	2352.53	756.51	65.35	11.58	18.0	36.0	0.502E-9
UNIV	TIME*VELOCITY*CASES(GROUP)	* 2352.53	****	65.35	****	****	36.0	****	****
ERROR TERM: TIME*VELOCITY*CASES(GROUP)									

AN ASTERICK (*) INDICATES IF APPROPRIATE ERROR TERM CANNOT BE FOUND. IF SO, RESIDUAL IS USED.

APPENDIX I

SUMMARIES OF NEWMAN-KEULS ANALYSES OF PAIN, RANGE OF MOTION, AND STRENGTH

Pain - Summary of the Newman-Keuls Analysis of the Interaction Effect:

```
*** MULTIPLE COMPARISONS ***
HYPOTHESIS TERM FOR COMPARISONS: GROUP*TIME
        ALPHA = 0.0500000
 ERROR TERM INCLUDES:          TIME*CASES(GROUP)

VARIABLE:   VAS1

     TIME      GROUP

   TIME3     LEVEL2    FREQ.  (  10.0)
                       ESTMEAN    7.30

   TIME2     LEVEL1    FREQ.  (  10.0) REQ DIFF     12.91
                       ESTMEAN   11.00 OBS DIFF      3.70
                                       S.E.         6.40
                                       D.F.        44.17
                                       SNK          2.02

   TIME1     LEVEL1    FREQ.  (  10.0) REQ DIFF     15.49     10.60
                       ESTMEAN   12.20 OBS DIFF      4.90      1.20
                                       S.E.         6.40      5.22
                                       D.F.        44.17     36.00
                                       SNK          2.42      2.03

   TIME3     LEVEL1    FREQ.  (  10.0) REQ DIFF     17.06     12.74     10.60
                       ESTMEAN   15.45 OBS DIFF      8.15      4.45      3.25
                                       S.E.         6.40      5.22      5.22
                                       D.F.        44.17     36.00     36.00
                                       SNK          2.67      2.44      2.03

   TIME1     LEVEL2    FREQ.  (  10.0) REQ DIFF     14.98     17.06     15.49     12.91
                       ESTMEAN   19.80 OBS DIFF     12.50      8.80      7.60      4.35
                                       S.E.         5.22      6.40      6.40      6.40
                                       D.F.        36.00     44.17     44.17     44.17
                                       SNK          2.87      2.67      2.42      2.02

   TIME2     LEVEL2    FREQ.  (  10.0) REQ DIFF     15.71     18.18     17.06     15.49     10.60
                       ESTMEAN   23.32 OBS DIFF     16.02*    12.32     11.12      7.87      3.52
                                       S.E.         5.22      6.40      6.40      6.40      5.22
                                       D.F.        36.00     44.17     44.17     44.17     36.00
                                       SNK          3.01      2.84      2.67      2.42      2.03

            ESTMEAN                              7.30     11.00     12.20     15.45     19.80     23.32
            FREQUENCIES                    (  10.0) (  10.0) (  10.0) (  10.0) (  10.0) (  10.0)
            GROUP                          LEVEL2    LEVEL1    LEVEL1    LEVEL1    LEVEL2    LEVEL2
            TIME                           TIME3     TIME2     TIME1     TIME3     TIME1     TIME2
```

Range of Motion - Summary of the Newman-Keuls Analysis of the Time Effect:

```
*** MULTIPLE COMPARISONS ***
HYPOTHESIS TERM FOR COMPARISONS: GROUP*TIME
        ALPHA = 0.0500000
 ERROR TERM INCLUDES:          TIME*CASES(GROUP)

VARIABLE:   ROM1

    TIME      GROUP

  TIME1     LEVEL2   FREQ. (   10.0)
                     ESTMEAN   108.30

  TIME1     LEVEL1   FREQ. (   10.0) REQ DIFF      11.21
                     ESTMEAN   124.10 OBS DIFF      15.80*
                                      S.E.          5.53
                                      D.F.         38.51
                                      SNK           2.03

  TIME2     LEVEL2   FREQ. (   10.0) REQ DIFF      10.02     11.21
                     ESTMEAN   126.60 OBS DIFF      18.30*     2.50
                                      S.E.          4.10      5.53
                                      D.F.         36.00     38.51
                                      SNK           2.44      2.03

  TIME2     LEVEL1   FREQ. (   10.0) REQ DIFF      14.83     10.02     11.21
                     ESTMEAN   133.00 OBS DIFF      24.70*     8.90      6.40
                                      S.E.          5.53      4.10      5.53
                                      D.F.         38.51     36.00     38.51
                                      SNK           2.68      2.44      2.03

  TIME3     LEVEL2   FREQ. (   10.0) REQ DIFF      11.78     14.83     10.02     11.21
                     ESTMEAN   133.90 OBS DIFF      25.60*     9.80      7.30      0.90
                                      S.E.          4.10      5.53      4.10      5.53
                                      D.F.         36.00     38.51     36.00     38.51
                                      SNK           2.87      2.68      2.44      2.03

  TIME3     LEVEL1   FREQ. (   10.0) REQ DIFF      16.58     11.78     14.83     10.02     11.21
                     ESTMEAN   137.80 OBS DIFF      29.50*    13.70*    11.20      4.80      3.90
                                      S.E.          5.53      4.10      5.53      4.10      5.53
                                      D.F.         38.51     36.00     38.51     36.00     38.51
                                      SNK           3.00      2.87      2.68      2.44      2.03

          ESTMEAN                          108.30    124.10    126.60    133.00    133.90    137.80
          FREQUENCIES                   (   10.0) (   10.0) (   10.0) (   10.0) (   10.0) (   10.0)
          GROUP                         LEVEL2    LEVEL1    LEVEL2    LEVEL1    LEVEL2    LEVEL1
          TIME                          TIME1     TIME1     TIME2     TIME2     TIME3     TIME3
```

Strength - Summary of the Newman-Keuls Analysis of the Time and Velocity Effects:

```
*** MULTIPLE COMPARISONS ***
HYPOTHESIS TERM FOR COMPARISONS: TIME*VELOCITY
        ALPHA = 0.0500000
 ERROR TERM INCLUDES:          TIME*VELOCITY*CASES(GROUP)

VARIABLE:   SIX1

    TIME      VELOCITY

   TIME1      240        FREQ.  (   20.0)
                         ESTMEAN    45.45

   TIME2      240        FREQ.  (   20.0) REQ DIFF      7.35
                         ESTMEAN    58.20 OBS DIFF     12.75*
                                          S.E.         3.66
                                          D.F.        57.04
                                          SNK          2.01

   TIME3      240        FREQ.  (   20.0) REQ DIFF      8.80      7.35
                         ESTMEAN    61.70 OBS DIFF     16.25*     3.50
                                          S.E.         3.66       3.66
                                          D.F.        57.04      57.04
                                          SNK          2.40       2.01

   TIME1      60         FREQ.  (   20.0) REQ DIFF     14.98     14.76     12.28
                         ESTMEAN    85.40 OBS DIFF     39.95*    27.20*    23.70*
                                          S.E.         5.44       6.04      6.04
                                          D.F.        24.39      34.74     34.74
                                          SNK          2.76       2.45      2.03

   TIME2      60         FREQ.  (   20.0) REQ DIFF     17.37     14.98     14.76      7.35
                         ESTMEAN   102.60 OBS DIFF     57.15*    44.40*    40.90*    17.20*
                                          S.E.         6.04       5.44      6.04      3.66
                                          D.F.        34.74      24.39     34.74     57.04
                                          SNK          2.88       2.76      2.45      2.01

   TIME3      60         FREQ.  (   20.0) REQ DIFF     18.22     17.37     14.98      8.80      7.35
                         ESTMEAN   109.60 OBS DIFF     64.15*    51.40*    47.90*    24.20*     7.00
                                          S.E.         6.04       6.04      5.44      3.66      3.66
                                          D.F.        34.74      34.74     24.39     57.04     57.04
                                          SNK          3.02       2.88      2.76      2.40      2.01

                ESTMEAN                             45.45     58.20     61.70     85.40    102.60    109.60
                FREQUENCIES                   (    20.0) (   20.0) (   20.0) (   20.0) (   20.0) (   20.0)
                VELOCITY                      240       240       240       60        60        60
                TIME                          TIME1     TIME2     TIME3     TIME1     TIME2     TIME3
```

APPENDIX J

PERCENTAGE OF GROUP RESPONSES

TO

EVALUATION FORM QUESTIONS

(1). Did you read the knee instruction/exercise sheet you were given? yes (T=C=100%) no

(2). Did you understand the instruction/exercise sheet?

most of it (T=C=90%) some of it (T=C=10%)

(3). Did you do what the the instruction/exercise sheet said?

week 1 most of the time (T=44% C=66%)

some (T=44% C=22%)

none (T=C=12%)

week 2 most of the time (T=12% C=56%)

some (T=66% C=34%)

none (T=22% C=10%)

week 3 most of the time (T=C=34%)

some (T=22% C=45%)

none (T=44% C=21%)

(4). Did you apply ice to your knee more than 3 times per day?

week 1	yes (T=C=20%)	no (T=C=80%)
week 2	yes (T=C=10%)	no (T=C=90%)
week 3	yes	no (T=C=100%)

(5). Did you use anything else such as a heating pad or whirlpool to make your knee feel better?

yes (C=20%) no (T=100% C=80%)

(6). Did you engage in any physical activities such as walking or swimming following surgery?

week 1 yes (T=60% C=70%) no (T=40% C=30%)

week 2 yes (T=80% C=70%) no (T=20% C=30%)

week 3 yes (T=90% C=100%) no (T=10%)

(8). Did your involvement in this study affect the way you looked after your knee following surgery?

yes (T=40% C=30%) no (T=60% C=70%)

(9). Did you understand the instructions the physiotherapist gave you?

most of them (T=100%) some none

(10). Did the visit by the physiotherapist affect the way you looked after your knee following surgery?

yes (T=12.5%) somewhat (T=75%) no (T=12.5%)

Note. The evaluation form was administered to subjects only once at the final test session. The values in parentheses adjacent to each answer on the evaluation form represent the percentage of subjects in the treatment and control groups who selected that particular response. Question #9 and #10 applied only to the treatment group. T = treatment group, C = control group.